objected to drawings 1, 5, 7, and 8 as failing to comply with 37 CFR 1.84 (g) because the margins are not acceptable. The Examiner also objected to drawings 1, 6, 8, and 9 because reference labels were not provided and drawing 10 because conductor line 32 is not labeled. Applicant appreciates the Examiner pointing out the deficiencies in the drawings. Applicant has corrected the drawings and submits amended drawings herewith.

The Examiner rejected claims 1-8 and 12-16 under 35 U.S.C. Section 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. Applicant is appreciative of the Examiner's suggestions regarding compliance with Section 112 and has incorporated those suggestions into amendments attached herewith.

The Examiner rejected claims 1-4, 5, 6, and 9-11 under 35 U.S.C. Section 102(b) as being anticipated by Powell et al. The Applicant has traversed the Examiner's written opinion and respectfully challenges the rejection.

The Powell patent discloses a crossover comprised of and in the following order: a substrate, a conductor, a dielectric, a ground and a conductor. In contrast, the Applicant's invention is a crossover comprised of and in the following order: a Fig 6 of Powell dielectric, a ground, a dielectric and a conductor. As one can appreciate, the Applicant's novelty in the invention includes the insulating effect of a ground sandwiched between two dielectrics, thereby shielding the top layer the top layer, which is the conductor. In contrast, the Powell patent does not disclose this added

insulating effect, whereby there is only a dielectric and a ground to shield the conductor.

Furthermore, the Powell patent discloses a crossover that is integrated into a circuit board during the circuit board manufacturing process. In contrast, the present invention as described in the specification and as claimed in the claims comprises a crossover component which is intended to be attached to the surface of a circuit board rather than integrated within it. This is a significant improvement over the Powell patent because it allows greater flexibility in manufacture of circuit boards and allows crossovers to be formed at a substantial cost savings over monolithic techniques. Applicant believes that the claims clearly distinguish over Powell and are not anticipated by Powell.

Claims recite "may be"

The Examiner rejected claims 1-4, 5, 6, 9-11, 12-14, and 16 under 35 U.S.C. Section 102(e) as being anticipated by Whybrew et al. The Whybrew et al reference discloses distributed ground pads for shielding crossovers of mutually overlapping stripline signal transmission networks. The Whybrew reference, similar to the Powell reference, contains multi-layer stripline architecture and discloses a crossover that is integrated into a circuit board. In contrast, the present invention discloses and claims a surface mounted component.

Specifically, the Whybrew patent discloses a crossover which, during the laminate structure manufacturing process, is integrated into a laminate structure consisting of multiple transmission networks. Applicant's invention is not integrated into the transmission network laminate structure during the laminate structure

manufacturing process, but may be applied to the laminate structure after it has been prepared. This allows crossovers to be prepared separately for use on multiple circuits. This produces a cost-saving by allowing inventory of crossovers to be used for a variety of applications rather than designed into specific circuit boards. Furthermore, crossovers can be tested and replaced individually instead of as a component of a larger and more complex circuit board. Applicant believes the present invention as claimed clearly distinguishes over the Whybrew et al reference.

Applicant believes that the set of claims is in condition for allowance and earnestly requests that the claims pass to issue. If the Examiner believes that contact with Applicant's attorney would aid in the examination of the application, the Examiner is requested to contact Applicant's attorney at the telephone number listed below. The Examiner is hereby authorized to charge any required fees not included herewith to Deposit Account 501-546.

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Fig. 2 is a cross-sectional view taken through line 11-H of Fig. 1;

Fig. 3 is a top view of a surface mount crossover component in accordance with a second embodiment of the present invention;

Fig. 4 is a cross-sectional view taken through line TV-N of Fig. 3;

Fig. 5 is a top view of a surface mount crossover component in accordance with a third embodiment of the present invention;

Fig. 6 is a cross-sectional view taken through line VI-VI of Fig. 5;

Fig. 7 is a perspective view of the surface mount crossover component shown in Fig. 5;

Fig. 8 is a top view of an alternative form of the surface mount crossover component in accordance with the third embodiment of the present invention;

Fig. 9 is a cross-sectional view taken through line IX-IX of Fig. 8; and

Fig. 10 is an exemplary RF integrated circuit incorporating the surface mount crossover component of the present invention.

Detailed Description of the Invention

Fig. 1 is a top view, and Fig. 2 is a cross-sectional view taken along line II-II of Fig. 1, of a surface mount crossover component 1 in accordance with a first embodiment of the present invention. The component includes a lowermost first dielectric layer 2 (see Fig 2), a ground plane layer 3 disposed above first dielectric layer 2, a second dielectric layer 4 disposed above ground plane layer 3, and a conductor line 5 disposed above second dielectric layer 4. Conductor line 5 traverses second dielectric layer 4 to provide an electrical path from one end of the crossover component to an opposed end thereof. The overall shape of the component is generally that of a parallelogram, for reasons of

manufacturing efficiency. It is understood, however, that the component can take any shape as long as the crossover function is achieved.

It can be appreciated from Fig. 2 that the surface mount crossover component can be manufactured using known materials (e.g., polymers, ceramics, and the like) and known strip line manufacturing techniques, such as those disclosed in U.S. Patent 4,821,007, the entirety of which is incorporated herein by reference. After all the layers of the component are so formed and laminated, it is preferred to form so-called "half-barrel" termination contacts to allow the component to be soldered to a circuit board using surface mount techniques. Specifically, an input termination contact 6 is formed in electrical communication with one end of conductor line 5, and an output termination contact 7 is formed on the other end, again, in electrical communication with conductor line 5. As is known in the art, it is preferred to bevel the sides of the crossover component to provide reliable electrical contact with conductor line 5. Figs. I and 2 show that ground plane layer 3 is recessed away from termination contacts 6 and 7 to insure electrical isolation between the termination contacts and the ground plane layer.

The crossover component of Figs. 1 and 2 can be used anywhere it is necessary to cross one conductor line over another conductor line already printed on a circuit board. For example, the component could be positioned over a printed DC control line, and termination contacts 6 and 7 could be soldered to an RF line that needs to cross the DC control line. The RF signal would flow through the crossover component via conductor line 5 without interference from the DC control signal flowing through the conductor line printed on the circuit, because dielectric layers 2, 4 and ground plane layer 3 electrically and capacitively isolate, respectively, the conductor lines from one another.

It will be apparent to the skilled circuit designer that the impedance of conductor line 5, including its termination contacts 6 and 7, must match the impedance of the system

in which the crossover component will be used. For example, a typical impedance for a high power amplifier in a wireless communication system is 50 ohms. The impedance of conductor line 5, carrying the RF signal, is controlled by the dielectric constant and thickness of dielectric layer 4, as well as the cross-sectional dimensions of conductor line 5 itself. As such, it is relatively easy to form conductor line 5 having an impedance of 50 ohms.

The overall shape of the component, as shown in the plan view of Fig. I, is 10 generally that of a parallelogram, for reasons of manufacturing efficiency. It is understood, however, that the component can take any shape as long as the crossover function is achieved. It is also preferred that the component have an aspect ratio greater than I to facilitate correct orientation during automated assembly.

In the event several conductor lines need to cross the conductor line(s) printed on the 15 circuit, a plurality of laterally spaced conductor lines 5 could be formed on dielectric layer. Each conductor line would be accompanied by corresponding termination contacts, and appropriate recesses would be formed in ground plane layer 3 to insure electrical isolation, as described above. An alternative design such as this will be explained below with respect to Figs. 8 and 9.

Fig. 3 is a top view, and Fig. 4 is a cross-sectional view taken along line IV-IV of Fig. 3, of a surface mount crossover component 21 in accordance with a second embodiment of the present invention. The component includes a functional surface mount component 22 (see Fig. 4), such as a XINGER® hybrid coupler manufactured by Anaren Microwave, Inc. A ground plane layer 23 is disposed on the upper surface of functional surface mount component 22 (the ground plane layer 23 is usually formed as a component part of the functional surface mount component). A dielectric layer 24 is disposed above ground plane layer 23, and a conductor line 25 is disposed above dielectric layer 24. Layers

23, 24 and 25 could be formed on the bottom surface of component 22 and achieve the same result. Conductor line 25 traverses dielectric layer 24 to provide an electrical path from one end of the crossover component to an opposed end thereof. Dielectric layer 24 and ground plane layer 23 electrically and capacitively isolate, respectively, the conductor lines from one another. Accordingly, current can flow through the crossover component via conductor line 25 without interference from current flowing through conductor lines of functional surface mount component 22.

As in the first embodiment, an input termination contact 26 is formed in electrical communication with one end of conductor line 25, and an output termination contact 27 is formed on the other end, again, in electrical communication with conductor line 25. Additionally, ground plane layer 23 is recessed away from termination contacts 26 and 27 to insure electrical isolation between the termination contacts and the ground plane layer.

In the event several conductor lines need to cross the conductor line(s) of functional surface mount component 22, a plurality of laterally spaced conductor lines 25 could be formed on dielectric layer 24. Each conductor line would be accompanied by corresponding termination contacts, and appropriate recesses would be formed in ground plane layer 23 to insure electrical isolation, as described above.

Fig. 5 is a top view, Fig. 6 is a cross-sectional view taken through line VI-VI of Fig. 5, and Fig. 7 is a perspective view of a surface mount crossover component in accordance with a third embodiment of the present invention. This surface mount crossover component is used to cross two conductor lines over one another within the body of the crossover

component itself. The surface mount crossover component 30 comprises first conductor line 32 and second conductor line 33 (see Figs. 2 and 6) that are capacitively isolated from one another by an interposed ground plane 42. The first conductor line 32 and second conductor line 33 extend along opposite diagonals of the component to allow appropriate spacing between the external termination points of the respective conductor lines. It is understood, however, that the conductor lines could extend from opposite sides of the component and still achieve the intended crossover function.

Fig. 6 is a cross-sectional view taken along line VI-VI of Fig. 5, and shows the individual layers of the surface mount crossover component. The component includes a bottom ground plane layer 40 that is electrically isolated from first conductor line 32 via an interposed first dielectric layer 41. An internal ground plane layer 42 is electrically isolated from first conductor line 32 via a second dielectric layer 43. The internal ground plane layer 42 is also electrically isolated from second conductor line 33 via an interposed dielectric layer 44. A top ground plane layer 45 is electrically isolated from second conductor line 33 via an interposed fourth dielectric layer 46.

The four dielectric layers insure that the first conductor 32, second conductor 33 and ground plane layers 40, 42, 45 are electrically isolated from one another within the body of the crossover component. The internal ground plane layer 42 insures that the first conductor line 32 is also capacitively isolated from the second conductor line 33. In this manner, a first signal (e.g., an RF signal) can be transmitted through the crossover component via first conductor line 32 without encountering any substantial interference from a second signal (e.g., a DC control signal) passing through the crossover component via second conductor line 33.

would have to be rotated 90° to insure that the first conductor line 32 and second conductor line 33 cross each other as shown in Fig. 5.

After all the layers of the component are formed and laminated, a first input termination contact 50 is formed on the upper left-hand beveled corner of the component as shown in Fig. 5, and a first output termination contact 51 is formed on the opposite corner, both in electrical communication with the second conductor line 33. A second input termination contact 52 and a second output termination contact 53 are formed in a similar manner in electrical communication with the first conductor line 32. As is known in the art, it is preferred to bevel the corners of the crossover component to provide reliable electrical contact with the first and second conductor lines 32, 33.

Figs. 5 and 7 also show that the termination contacts extend onto the upper and lower surfaces of the crossover component. As best seen in Fig. 7, the top and bottom ground plane layers 45, 40 are formed in the shape of a cross and are recessed away from those portions of the termination contacts that reside on the top and bottom surfaces of the crossover component. This insures electrical isolation between the top and bottom ground plane layers and the adjacent termination contacts. The orientation and shape of internal ground plane layer 42 is the same as that of top and bottom ground plane layers 45, 40 shown in Figs. 5 and 7. So-called "half-barrel" termination contacts 60 are formed on each side of the crossover component to provide sufficient electrical contact with the ground plane layers, particularly the internal ground plane layer 42.

While the input and output termination contacts shown in Figs. 5 and 7 extend along the entire height of the crossover component, it is possible to form the input and output contacts for the lower, first conductor line 32 to a height that equals the position of the first conductor line within the stacked structure of the crossover component. While such a design

alteration should improve the RF performance of the crossover component, it would require that the component be properly oriented before mounting on an integrated circuit board. That is, while either the top or the bottom ground plane layer of the component shown in Figs. 5-7 could be mounted to an integrated circuit board, the alternative design described above would require that the bottom ground plane 40 be mounted on the integrated circuit board, so that the RF line, for example, on the integrated circuit board could be soldered, using surface mount techniques, to the input and output termination contacts in communication with the first conductor line 32.

Fig. 8 is a top view, and Fig. 9 is a cross-sectional view taken along line IX-IX of Fig. 8, of an alternative surface mount crossover component 30 in accordance with the third embodiment of the present invention. Like reference numerals designate like components in Figs. 5-9 and may not be described in detail for all figures. The surface mount component shown in Figs. 8 and 9 includes a first conductor line 32 and two second conductor lines 33a and 33b. This component can be used when two conductor lines (e.g., RF signal lines) must cross another conductor line 15 (e.g., a DC supply/control line).

Fig. 10 shows an exemplary integrated circuit board that is commonly used in high power amplifiers of wireless communication systems. The circuit board 80 includes an RF signal line 81, which passes through a hybrid coupler 82, such as a XINGER® hybrid coupler manufactured by Anaren Microwave, Inc. The hybrid coupler splits the signal into two signals carried by conductor lines 83 and 84. The signals pass through semiconductor amplifiers 85 and 86, before being re-combined by a second hybrid coupler 87, to form an output signal carried by conductor line 88. Each amplifier 85 and 86 includes a DC supply/control line 89. It can be seen from Fig. 10 that control line 89 must cross RF lines 83 and 84 to reach amplifier 86, for example.

In accordance with the present invention, if DC control line 89 is printed on the circuit board, then surface mount crossover component 1 could be mounted easily to the surface of the integrated circuit board to allow the RF lines 83 and 84 (passing through conductor lines 5) to cross DC control line 89. Two surface mount components could be used, or two conductor lines could be formed on one crossover component 1 to allow both RF lines 83 and 84 to cross line 89 in a single component. Another alternative would be to break the DC control line 89 and use two crossover components 30 to allow RF lines 83 and 84 (passing through conductor lines 33--Fig. 5) to cross DC control line 89 (passing through conductor line 32--Fig. 5). Yet another alternative would be to run DC control line 89 over hybrid 10 coupler 82 using crossover component 21 shown in Figs. 3 and 4.

It is clear from the above description that the surface mount crossover components of the present invention can be mounted easily to the surface of an integrated circuit board to allow signal lines to cross one another substantially free of interference. In particular, the surface mount crossover components in accordance with the present invention provide an easy and inexpensive solution to the problem of crossing DC control lines and RF signal lines. It is no longer necessary to bury at least one of the lines within the integrated circuit board itself, as discussed in the '375 patent. Accordingly, a substantial cost savings can be realized by using the surface mount crossover component according to the present invention.

The surface mount crossover component of the present invention also provides superior microwave performance when compared to the RF crossover described in the '375 patent, because the RF signal line is capacitively isolated from the DC control line by the presence of an internal ground plane layer interposed between the conductor line carrying the RF signal and the conductor line carrying the DC control signal.